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Car Drivers' Pattern of Eye Fixations on the Road and in the Laboratory

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by

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Car drivers' eye fixations were registrated when driving a car on the road and when viewing a slide in the laboratory which shows the same traffic situation. Even when the Ss of the second group were instructed to observe the presented slide as if they were driving there, they fixated their eyes on well defined targets with quite different frequencies than those Ss who actually drove the car on the road. Furthermore, in the laboratory there was a tendency toward prolonged fixation times as compared to on the road driving condition. The results suggest that the Ss on the road fixated more task oriented targets.

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SUMMARY

Car drivers' eye fixations were registrated when driving a car on the road and when viewing a slide in the laboratory which shows the same traffic situation. Even that the Ss of the second group were instructed to observe the presented slide as if they were driving there, they fixated their eyes on well defined targets with quite different frequencies than those Ss who actually drove the car on the road. Furthermore, in the laboratory there was a tendency toward prolonged fixation times as compared to on the road driving condition. The results suggest that the Ss on the road fixated more task oriented target and picked up also more information than their counterpartners in the laboratory.

1. INTRODUCTION

Investigations on the pattern of eye fixations are not only of interest when studying the peripheral mechanisms of information input or when investigating those of the motoric activity underlying, for instance, the saccads. The patterns of the movements in relation to the separate fixations of the eye reflects, presumably, the cognitive activities which govern the program of eye movements (MACKWORTH and BRUNER, 1970). Therefore, the measureable <u>peripheral activity</u> of the eye is assumed to correspond with <u>central processing</u> mechanisms. For example, YARBUS (1967) showed that the way people observe pictures depends on the target presented, the person observing it as well as on the task the S is engaged with. Also, when the same picture is presented repeatedly a different pattern of eye fixations can be obtained. YARBUS (1967) suggests, therefore, that there is a relationship between thinking and seeing. Nevertheless, a S's pattern of eye fixations depends not only on long term variables, but also on his momentary condition. From studyies of car drivers, it is known that, for example, alcohol consumption (BELT, 1969; MORTIMER and JORGESON, 1972) or fatigue (KALUGER and SMITH, 1970) also influences the pattern of fixations. It is, therefore, suggested that peripheral information input is closely related to processing in higher level mechanisms.

Only a little is known about the relationship between patterns of fixations observed in real conditions, e.g., when steering a car, to that of observing a similar optical array in the laboratory. This issue can also be considered within a more general framework. Every experimental paradigm in the laboratory represents an artificial situation but the design should, nevertheless, reflect reality. By operationalyzing the crucial variables, the general issue arises as to whether the obtained relationship between the considered variables in the laboratory condition are also valid in the real circumstance. Furthermore, it is not yet known, as FISCHER (personal communication) emphasizes, how the specific experimental design influenced the particular relationships obtained, as well as what the magnitude of the dependent variables observed were.

The two present experiments were designed in order to compare car drivers' visual search activity in a dynamic situation (when driving), with a more static one (when observing a slide of the same traffic conditions). The main goal of this study is to find out whether car drivers fixate similarily in both conditions on the well defined elements of the road. Any difference obtained would indicate that the S weights the importance of the elements of the road depending on the experimental paradigm. Furthermore, the question of whether any difference occurs in the Ss' processing rate between these designs should also be investigated.

2. METHOD

Two experiments were carried out in order to compare the obtained pattern of eye fixations under different conditions. Common then to both experiments is the registration of eye fixations. The registration of eye fixations was carried out by using a NAC III Eye-Marc-Recorder connected to a videorecorder within a visual field of 30°. The records were played on Grundig Slow-Motion-Apparatus with the capacity for a single frame analysis with a frequency of 50 frames per each recorded second.

2.1. EXPERIMENT 1: DRIVING ON THE ROAD

The drivers negotiated unexpectedly a building site, consisting principally of a crané which totally blocked the one way road the drivers used. In order to pass the building site, the S had to drive for a distance on the road after which it then became necessary to drive on the left side-walk by utilizing a small "ramp" as shown in Figure 1. A more detailed description is given elsewhere (COHEN, 1976), therefore, only the essential characteristics of the road elements will be given here. These were (1) the road, (2) the ramp, (3) the side walk, (4) the wall of the building on the left, (5) the crane and (6) elsewhere. Fixation times and rates were analyzed.

Subjects

The five Ss participating in this experiment were aged between 22 and 32 years. No S was told that he was going to be faced with a building site. Of course, no instructions were given other than to drive the car as told 15 minutes beforehand.

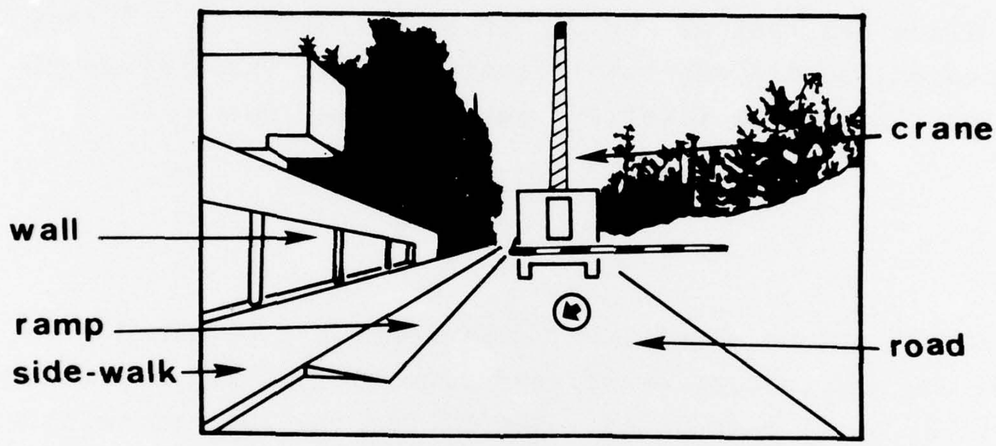

Figure 1: The building site from which a group of Ss (N=5) passed when driving a car and of which another group licensed Ss (N=9) observed as a photographed slide in the laboratory. The targets of fixations evaluated are indicated by arrows.

2.1.1. RESULTS

The results indicate that no difference in fixation times were obtained between all of the six categorized elements of the road (X^2=3.87; df=4, $p > 0.05$). The Spearman rang correlation coefficient indicates a relationship between fixation times and rates (r_s=0.97; df=5, $p < 0.05$). It was discerned that as the number of fixations on a target increased, so did the total fixation time. The average fixation time of all fixations amounted 0.41 sec.

Eventhough no significant difference was obtained between the six categories of road elements, it is surprising that the small ramp was fixated on for the longest relative time (31.9 %) and that the obviously obstructive crane was the shortest fixation (9.9 %; see Fig. 2a). When considering not only the obstructiveness but the importance of the ramp for driving, then this finding is reasonable. Eventhough the ramp is physically a small element, is had the effect of determining the driver's path of driving due to the fact that he had to drive on it in order to avoid the crane.

2.2. EXPERIMENT 2: OBSERVING THE TRAFFIC CIRCUMSTANCES IN THE LABORATORY

The second experiment was designed differently in two respects from the first one. In the laboratory, an artificial situation was created. Therefore, the Ss' perceptual activity did not fulfill its primary function, that is, to survive. The Ss, were not required to carry out any sensomotoric activity and did not, therefore, receive any proprioceptive information. They fulfilled only the instructions given. Another essential difference between both experiments concerns the nature of visual information presented. In this experiment, the Ss were presented with a slide of the real situation as the drivers in experiment 1 saw it from one well defined position only. Therefore, the information presented was of a static nature.

The results of experiment 1 were considered in order to choose the specific slide to be presented. Because the ramp was fixated on most frequently, that view of the building site was used out of all photos taken, where the ramp was most emphasized (see Fig. 1). Because of this emphasis, it was assumed that the possibility of fixating on the ramp should be increased.

The selected slide was presented at a distance of 135 cm from the Ss, corresponding to a visual angle of 22^{o}.

The Ss were told that a slide will be presented, for only a short time, that shows a traffic situation. Their task was to observe this slide as if they had to drive at the same place.

For data evaluation, a period of observation of approximately five seconds was considered. The analysis began with the first fixation after the onset at the stimuli occured and ended after five seconds were analyzed, but prolonged until the ending of the fixation already had been begun. A total of 2422 frames were considered.

Subjects

Unfortunately, the Ss who participated in experiment 1 were not available any more. Therefore, in this experiment, nine licensed Ss participated (a tenth S was excluded, because he had no license). Their ages ranged between 18 and 27 years and all of them had normal visual acuity.

2.2.1. RESULTS

The six categories of road elements were fixated in this experiment with a significantly varying number of fixation between them as well as for different total durations (X^2=19.61; df=5, $p < 0.05$ and respectively (X^2=403.7; df=5, $p < 0.05$). When observing the slide, the crane was the target of fixation for the longest total time (13.68 sec) followed by "elsewhere" (11.34 sec), the side-walk (10.54 sec), the wall (8.64 sec), the ramp (2.84 sec) and the road (1.40 sec). The respective relative fixation times are shown in Figure 2b. The total fixation times on each target do not correspond significantly with the total number of fixations on the same element of the road (r_s=0.89;

df=5, $p > 0.05$) because the average fixation times on the side-walk (0.72) as well as on the crane (0.59) are quite long. The average duration of all fixations amounted to 0.52 sec.

3. COMPARISON BETWEEN BOTH EXPERIMENTS AND DISCUSSION

An obvious difference between both experiments is shown in Figure 2 which clearly indicates that a significant difference in fixation times on the elements of the road was obtained (X^2=1064.3; df=5, $p < 0.01$). This result indicates that the time sharing between different targets is completely different when a S is actually driving than when he is observing the same traffic situation in the laboratory. On the road, the drivers fixate most frequently on the small ramp but this is not so in the laboratory. When the Ss were presented with a slide, they fixated most frequently on the obstructive crane which was seldomly fixated in the real situation. When driving, the crane seemed to direct the drivers' attention toward the path of driving in contrast to the laboratory conditions. It therefore seems that those Ss who drove a car directed their attention to the more important, task specific targets than did the Ss in the laboratory. In any case, it is clear that a driver's visual search strategy on the road can not be replicated in the laboratory when viewing a static picture. Another support that tends to the idea of less task oriented visual input in the laboratory can be derived from analyzing the frequencies with which the targets were fixated. Those targets which were categorized as "elsehwere" (e.g., trees in far distance, the rampant on the road's far right side etc.) were quite frequently fixated on in the laboratory eventhough they have no specific importance for driving. It seems that the Ss in the laboratory fixated on the targets which corresponded to their general interest rather than to their importance for driving, as compared to real driving conditions (see Fig. 2).

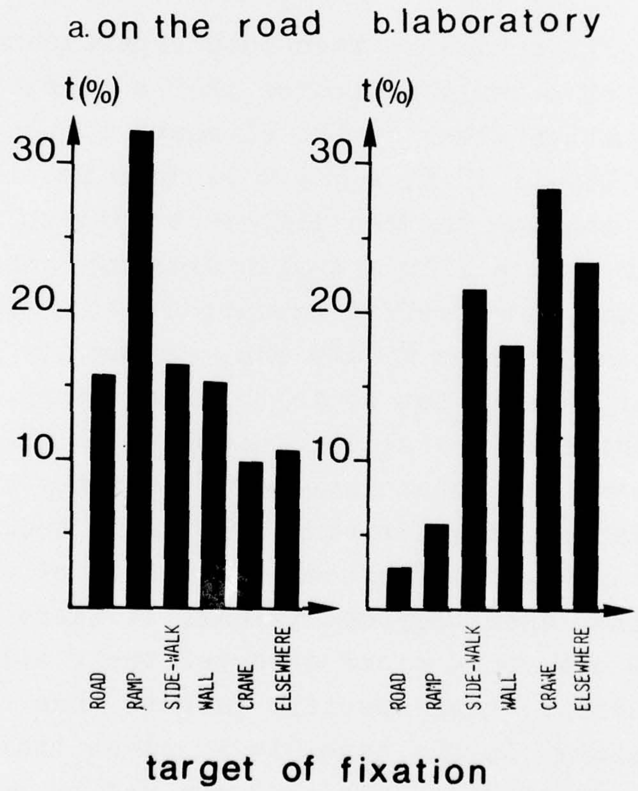

Figure 2: The total fixation time in percentage devoted to well defined targets (a) on the road and (b) in the laboratory.

A further difference between both experiments relates to the observed fixation durations. The mean fixation time in field conditions amounted 0.41 sec as compared to 0.52 sec in the laboratory conditions. Eventhough the difference between the average durations is approximately 25 %, it is not significant because of the broad distribution of single fixation times. In any case, the fixation rate was greater when driving as compared to when viewing a slide on all targets of fixations defined. The greater fixation rate on the road might be attributed to a correspondingly greater rate of information picked up which, presumably, correlates to the rate of information processed. This assumption is also supported by the fact that in experiment 1 those drivers who had a shorter fixation time on the average preferred to drove their car faster. Presumably, they did so, because they could process the information required for correct driving more rapidly than could the other Ss who manifested an average longer fixation time (see COHEN, 1976). This suggested relationship between the mean fixation times and the processing capacity is supported by studies in which the central processing mechanisms were inhibited by, for example, alcohol (BELT, 1969; MORTIMER and JORGESON, 1972), by carbonmonixide (SAFFORD, 1971; cit. in BHISE and ROCKWELL, 1971) or by fatigue or sleep deprivation (KALUGER and SMITH, 1970). In all of this studies, prolonged fixation times were observed. Furthermore, children, who presumably still posess less developed processing centers than do adults, also have a slight tendency toward prolonged fixation times (e.g. MACKWORTH and BRUNER, 1970). It should be mentioned that the mean and not the single fixation time is of importance.

It was suggested that the shorter the mean fixation time the greater the information input occuring and vica versa, assuming information is picked up in "single packages" (GAARDER, 1975). This relationship indicates that the Ss in the laboratory might have picked up less total information than the drivers on the road, perhaps because inadequate information processing on the road can ultimately lead to driving mishaps, whereas no crash can occur in the laboratory.

The results of both experiments discussed above indicate a discrepancy between the real and the simulated situations as observed in terms of visual search. For example, eventhough the ramp was emphasized in the slide presentation, it was less frequently fixated on than while actually driving. Several reasons might account for the obtained differences. The most obvious experimental variable is the use of a static optical array in experiment 2 as compared to real movement in experiment 1. Therefore, in a future experiment, a film could be used instead of a slide for studying similar paradigms. A further explaination for the observed differences might be the possibility that drivers use a task specific visual search strategy in field situations which, presumably, can not be replicated due to verbal instructions. It is also possible that Ss can not recognize in the laboratory the importance of different targets by reasoning as adequately as drivers on the road do. It can be furthermore assumed that the lack of proprioceptive information input, and sensomotoric activity etc. influences the way Ss observe a static traffic situation as presented in the laboratory.

In the both experiments, similar yet different situations were compared. It is, nevertheless, suggested that even in quite sophisticated simulations of field situations to be used as experimental designs in the laboratory, a discrepancy between the both might exists, and therefore, there is a necessity to validate the presuppositions assumed. Of course, the more sophisticated an experimental simulation is, the better correspondance between field and experimental conditions might be assumed. Nevertheless, a possible discrepancy between both situations can only be reduced and never totally excluded.

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